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ABSTRACT

Mathematics achievement of Elementary Secondary Education Act Title I students was evaluated, using RMC Model B, the control group model. The third-grade students in 8 of 17 Title I elementary schools and the fifth-grade students in the remaining 9 schools were chosen for the pilot project. The remaining third-and fifth-grade students served as the control groups for this experiment. The experimental treatment had two parts: inservice workshops for the teachers and demonstrations by mathematics project specialists in the classroom. The emphasis of the training and the demonstrations in the classrooms was on the use of manipulative materials, such as Cuisenaire rods, with the intention that learning by manipulation would precede symbolic activities by the children. For both third- and fifth-grade children, the pilot project children's post test means scores were not significantly different from their respective control groups. The application of analysis of covariance to the data produced the same result. (CTM)

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USING THE TITLE I CONTROL GROUP MODEL FOR EVALUATION RESEARCH AND DEVELOPMENT OF A SUPPLEMENTAL MATHEMATICS PROJECT FOR THIRD AND FIFTH GRADE STUDENTS

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Using the Title I Control Group Model for Evaluation Research and Development of a Supplemental Mathematics Project for Third and Fifth Grade Students

Federal guidelines regarding the evaluation of ESEA Title I projects permit districts to select one of three models for evaluating the impact of Title I upon student achievement. Model B, the control group model, is considered to yield the best estimate of the effect of the Title I treatment but is also the most difficult to implement. In addition to the near impossibility of assigning students to experimental and control groups in the public schools (Shaver, and Norton, 1980), especially for year-long treatments, Title I guidelines governing student selection criteria, i.e., that students scoring lowest on the selection device be served first, also mitigates against using Model B. Despite these difficulties, there are certain situations where the control group model may be applicable. One such instance is the evaluation of pilot projects designed to try out new service delivery strategies for Title I or to determine the effect of providing Title I services in additional curriculum areas.

The Title I Mathematics Pilot Project was in its first year of development in 1978-79. It was the first Title I Elementary School project to focus exclusively upon mathematics. The predominant goal of Title I for many years had been the improvement of reading comprehension. The mathematics project was developed as a pilot project at two grade levels, because the provision of supplementary mathematics services was an innovation for the program and also because only limited funds were available for mathematics.

The pilot project was unique in that it was the only Title I project in the school district that was experimental in both its conception and its research design, utilizing a service-delivery model that was a compromise between a pullout and a mainstream program. The project design called for three Mathematics Project Specialists (MPSs) to provide mathematics inservices to teachers and to follow up the inservice sessions with classroom demonstrations with small groups of target students. This role description was an innovation in that the same people providing a series of inservice training workshops were also showing teachers how to apply the new methods within the regular classroom context. This not only lent credibility to the inservices from the viewpoint of the classroom teachers (who were able to see the teaching strategies in action) but also ensured a greater understanding of target students' learning needs on the part of the resource teachers.

Method

Sample

Fifty-seven treatment group and 44 control group students rated very low in mathematics achievement by their teachers were selected for the research sample in Grade 3. Forty-seven treatment group and 59 control group Grade 5 students were selected on the basis of low test scores, stanines 1-2, on the Stanford Mathematics Test, Primary II, administered to Grade 4 students the previous fall.

Evaluation Design

Model B, the Title I control group model was used to evaluate the impact of the project. Using this model, posttest Normal Curve Equivalent (NCE) means of the Title I group and a control group were compared. Posttest means were adjusted for differences through analysis of covariance on the basis of pretest scores.

Grade 3 students and teachers in eight of 17 Title I Elementary Schools participated in the Mathematics Pilot Project; Grade 5 students at those schools served as the control group. Grade 5 students and teachers in the remaining nine schools participated in the Mathematics Project while Grade 3 students served as the control group. Schools were placed into treatment and control groups on an arbitrary basis with large and small schools in both groups. Therefore, every Title I school received project services, scarce resources could be evenly allocated and Model B could be implemented using the Title I population as a control.

Even though a random procedure could not be used to select the students, pilot and comparison groups were believed to be random in effect or equivalent to one another. The pretest results supported this assumption, and analysis of covariance was used to adjust for minor pretest differences in estimating the Title I treatment effect.

Students in the pilot and comparison group were pretested during the week of September 25, 1978 and posttested in the week of April 30, 1979 (Grade 5) and May, 1979 (Grade 3) in small groups by Title I staff who had received inservice training in mathematics test administration. Grade 3 students were pretested on the California Achievement Test (CAT/C), Form C, Level 11, Mathematics subtest. The pretest administered was two grade levels below grade level (Level 11 was normed for Grades K.6 - 1.9). Grade 3 students were posttested on the CAT/C, Level 12, Mathematics test, a test that was one year below grade level (Grades 1.6 - 2.9).

Grade 5 students were pretested one level below grade level on the Stanford Mathematics Test, Primary III, Mathematics Computation pretest. (Pretesting was done for the purpose of determining equivalence

between pilot and control groups, not for pre- and posttest comparisons.) Grade 5 students were posttested on the CAT/C, Level 14, Mathematics subtest, a test that was one level below grade level.

Out-of-level raw scores were converted to in-level percentiles and NCEs through the use of the Expanded Standard Scores Scale provided by the test publisher.

The results from the CAT/C, Level 14, Mathematics Computation subtest were used to fulfill the reporting requirements of Model B1 since only that part of the mathematics test was given in accordance with the standardization procedures specified by the test publisher. The Mathematics Concepts and Applications subtest was read orally to all the students since many of the students were low-proficiency readers. The oral administration of the test was at variance with the procedures used in norming the test. Therefore, only raw scores, not NCEs were used in reporting the results for the Concepts and Applications subtest for Grade 5 students to the State Education Agency.

Brief Program Description; the Title I "treatment"

Title I Mathematics Pilot Project was a deliberate intervention into the mathematics curriculum of low achievers. It was an attempt to train teachers in the latest instructional techniques for using manipulative mathematics materials, e.g., Cuisenaire Rods, etc., in the development process. Suydam and Higgins (1977) in an extensive review of the literature regarding the use of manipulatives in instruction, recommended that they be an integral part of instruction at the elementary level. The Title I project was supplemental to and compatible with the district mathematics program in that Cuisenaire Rods and other

manipulatable materials were provided for all elementary classrooms in the district in 1977-78. Some district inservices were given during the year that the mathematics program was initiated but it was felt that more inservice training was needed to ensure the frequent and proficient use of manipulatives in the classroom mathematics program.

The training of teachers had two components. The first was an inservice workshop where teachers used a variety of manipulative aids themselves during presentations by the Mathematics Specialists showing how manipulatives are used in instruction to build concepts. Following the inservices the resource teachers, called Mathematics Project Specialists, worked with small groups of three to eight children within the classroom to demonstrate the use of the manipulatives in instruction. The intention of the instructional model is that the children will use the manipulative aids themselves to develop or discover mathematical relationships before moving to the symbolic level.

Three mathematics project specialists forming a team with different strengths implemented the project. One project specialist, a former high school mathematics teacher, had a master's degree in mathematics and had previously worked in the district mathematics staff development and text book adoption activities. Including a teacher with an extensive background in mathematics was a key factor in the project, since elementary teachers typically do not have a strong mathematics background. Another had been active in the district mathematics textbook adoption process and had been a Title I program assistant. The third was an experienced and successful primary grade teacher.

An orientation meeting for third and fifth grade teachers participating in the Title I Mathematics Pilot Project was held in mid-September. Mathematics Project Specialists also met with each principal at his/her school to explain the project and to arrange space for pretesting of small groups of project participants later that month. At these meetings it was explained that the project should include both inservice and classroom demonstrations by project specialists. Later, the mathematics project specialists met individually with each teacher at his/her school to discuss the needs of target students and to establish a working relationship with classroom teachers as part of the basis for future classroom demonstrations. Teachers participating in the project were nonvolunteers and the implementation procedures took this into account. In late October voluntary geometry workshops were given for Grade 3 and 5 teachers after school dismissal. After these workshops, the project specialists visited each classroom to observe the behavior of target students during the mathematics period. There were 35 classrooms in 17 elementary schools participating in the project. As explained previously, the pilot project was implemented at only one grade level, 5 or 3, at each school.

Two mathematics inservices focusing upon the development of mathematics concepts using manipulatives and the school district mathematics educational philosophy were given in November and January. Among other things, the educational philosophy focused upon building insight and understanding of mathematics and avoiding introducing algorithms, formulas, shortcuts and rote learning too early. Manipulatable materials such as Cuisenaire Rods and the Powers of Ten Kit were used to model both language and notation for development of mathematics relationships and

ideas. Strategies were shared which provided increased opportunities for students to experiment, find patterns, and understand their own solution method. The importance of students having systematic experiences with a wide range of problem solving methods, including estimation, trial-and-error, and logical processes, was stressed.

Participating teachers were given one-half day released time to attend the inservices. Each inservice was followed by three consecutive days of Mathematics Project Specialist demonstration lessons in the classroom with small groups of target students. Three days were considered a minimum amount of time for teaching a concept. Classroom teachers selected the specific mathematics concepts to be demonstrated and were encouraged to observe the teaching techniques used by the Project Specialists. Title I aides were included in the January workshop and an inservice was given to aides in February. Final inservices were given in late April. A more complete report of the implementation of the project is found in the Evaluation Report for the 1978-79 ESEA Title I Elementary Schools Project in Grades 2-6 (Slaughter).

Results

Results for the Third Grade Pilot Project. There was a small, .9 NCE, difference in favor of the comparison group on the pretest. Pretest means were not significantly different. Tallmadge and Wood (1976, p. 49), stated "If the mean pretest scores of the two groups differ by 1 NCE or less, or by 3 percent or less of the observed raw score range, then the mean posttest score of the control group can be used as the no-treatment expectation." However, in order to obtain

a more precise estimate of the treatment effect, a covariance analysis was used. This method was used because assignment of groups was believed to be random in effect. The data presented in Table 1 indicated that the pretest covariate had a significant effect on the posttest but the two groups did not differ significantly on the posttest.

Table 1. Analysis of Covariance on the CAT/C, Level 12, Mathematics NCEs for Grade 3 Title I Mathematics Pilot Project and Comparison Group Students

Source	Sum of Squares	DF	F	Signif. of F
Covariates, NCE Pre	4215.2	1	72.9	0.00
Between Groups	106.9	1	1.8	.17
Within Groups	5662.1			

Table 2 shows that the pilot group scored 1.5 NCEs higher than the comparison group on the posttest. When posttest scores were adjusted for pretest differences, the pilot group scored 2.0 NCEs higher than the comparison group. Therefore, using Model B1 of the Title I Evaluation and Reporting System to analyze the data, the NCE gain for the Title I students is 2.0 NCEs and the objective for the project was attained. However, from a scientific perspective of experimental design, there were no differences between the two groups. Furthermore, the differences in raw score means was also miniscule.

Table 2. Posttest NCE and Raw Score Means Adjusted Through Analysis of Covariance on the CAT/C, Level 12, Mathematics Test for Preselected Grade 3 Pilot and Comparison Group Students

Group	N	Unadjusted Mean	Adjusted Mean
NCEs			
Pilot	57	22.0	22.2
Control	44	20.5	20.2
Difference		1.5	2.0
Raw Score[1]			
Pilot	57	40.7	40.8
Control	44	39.5	39.2
Difference		1.2	1.6

[1]Note: There were 66 possible raw score points.

The preceding analysis is all that is required by the Users' Manual (1976) for implementing Model B. The testing of assumptions underlying the use of covariance analysis is not called for. However, McNeil (1980) has suggested that evaluators test for interaction effects before interpreting results of analysis of covariance. Figure 1 shows the regression of posttest on pretest. The regression lines suggest a possible disordinal interaction indicating more rapid progress of pilot students. A statistical test of this showed that the interaction term was not significant $F(3, 97) = 2.34$, $p < .129$.

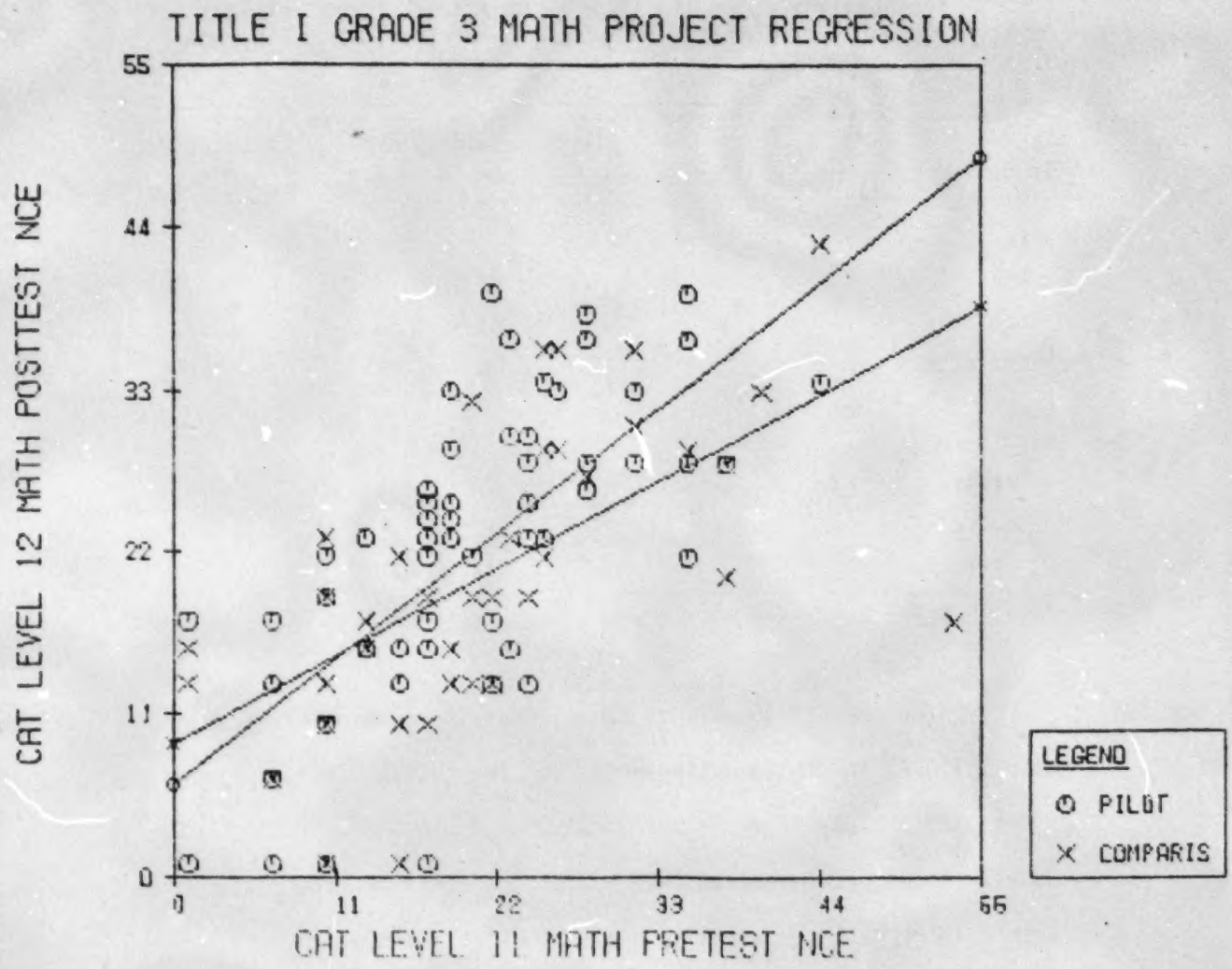

Figure 1. Regression of posttest on pretest for grade three students.

The data in Table 3 showing a 1.7 NCE gain between pre- and posttesting for the pilot target group and an NCE loss of .7 NCEs for the comparison group indicated that the Model B results were similar to those obtainable through Model A, a pre- to posttest design. The average NCE equalled a percentile of 7.9 on the pretest for the pilot group and a percentile of 9.2 on the posttest. The control group was at a percentile of 8.1 on the pretest and 8.6 on the posttest. Percentiles tend to be lower on out-of-level tests than they would be on in-level tests (Slaughter and Gallas, 1978).

Table 3. Differences Between Pre- and Posttest Correlated NCE Means for Grade 3 Pilot and Control Students on the CAT/C, Level 12, Mathematics Test

Group	N	Pretest M	Pretest SD	Posttest M	Posttest SD	Diff.
Pilot	57	20.3	9.2	22.0	10.3	1.7
Control	44	21.2	11.1	20.5	9.6	-.7

Results for the Grade 5 Mathematics Pilot Project. The one point difference between raw score means was not statistically significant. However, since this difference was slightly more than 3 percent of the observed raw score range of 23 points, an analysis of covariance to adjust posttest means for pretest differences was performed. As shown in Table 4, an analysis of covariance indicated that pretest scores had a significant effect upon the posttest and that after adjusting for this, posttest means were not significantly different. Figure 2 indicates that the regression lines of posttest on pretest were parallel.

Table 4. Analysis of Covariance on CAT/C, Level 14, Mathematics Computation Subtest, NCE Means for Grade 5 Pilot and Comparison Group Students

Source	Sum of Squares	DF	F	Signif. of F
Covariates	4440.2	1	29.6	0.00
Between Groups	194.8	1	1.3	.26
Within Groups	15445.7	103		

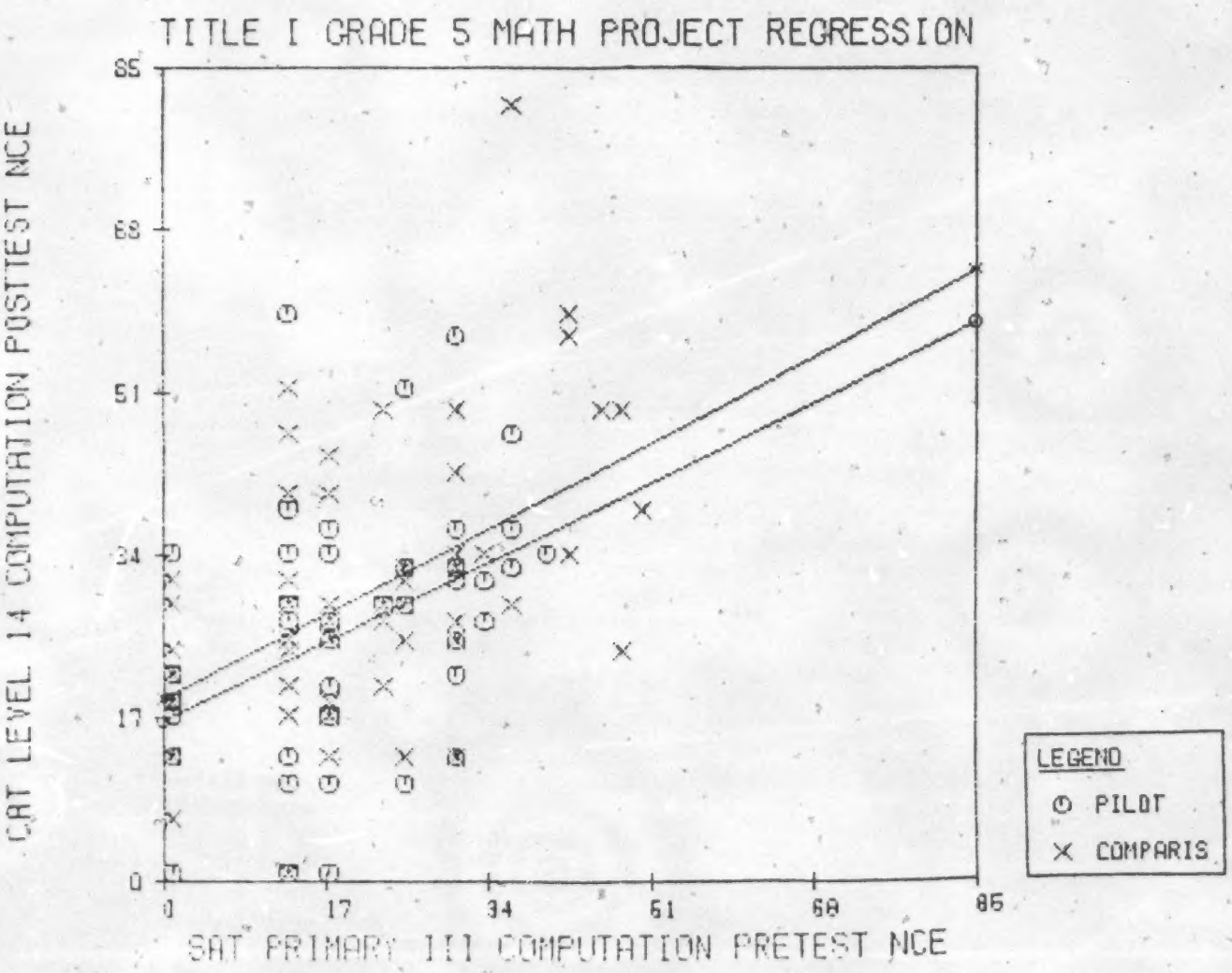

Figure 2. Regression of posttest on pretest for Grade 5 students.

Table 5 shows that the adjusted mean of the pilot group was 2.7 NCEs lower than that of the comparison group on the CAT/C, Level 14, Mathematics Computation subtest, given in April 1979 to Grade 5 students. The mean NCE for the pilot group equalled a percentile of 12.9 while the control group was at a percentile of 17.6. Therefore, using Model B1 the objective for Grade 5 was not attained. Since differences between the groups were too small to attain statistical significance, the NCE "loss" should be considered inconsequential. Experimentally, the results for Grade 3 and 5 are the same in that no statistically significant improvement could be attributed to an effect of Title I.

Table 5. Posttest NCE Means Adjusted by Analysis of Covariance for Preselected Grade 5 Pilot and Control Students on the CAT/C, Level 14, Mathematics Computation Subtest

Group	N	Unadjusted Mean	Adjusted Mean
Pilot	47	26.2	27.0
Control	59	30.4	29.7
Difference		-4.2	-2.7

The raw score means of the pilot and comparison group (for two subtests) were examined. The possible distortion caused in data by converting raw scores to NCE units was described in the first Title I evaluation report in the school district using NCEs (Slaughter, 1976-77, pp. 32-33). It was noted that while NCEs are useful for aggregating data at the federal level, improvement in raw score terms will continue to be

important for evaluating program outcomes at the local level. Table 6 shows that pilot students scored higher on the Concepts and Applications subtest when scores were controlled for initial differences. These differences were not significant.

Table 6. Posttest Raw Score Means Adjusted for Analysis of Covariance for Grade 5 Pilot and Control Students on the CAT/C, Level 14, Mathematics Computation, and Concepts and Applications Subtests

Test and Group	N Items	N Students	Unadjusted Mean	Adjusted Mean
Concepts and Applications	45			
Pilot		47	22.1	22.4
Control		49	21.2	20.9
Difference			.9	1.5
Computation	40			
Pilot		47	18.4	18.8
Control		49	20.3	20.0
Difference			-1.9	-1.2

Discussion of Results

The Mathematics Pilot Project was in its first year of development in 1978-79. Except for the planning that was done in preparing the Title I Application, the developmental planning for project implementation did not begin until fall 1978. Therefore, the development of the program and its "field-testing" occurred within the school year. As such, these results should not be interpreted as a final summative evaluation.

One aspect of the Title I "treatment" which should be considered is the limited number of sessions in which the mathematics project assistants directly instructed target students. The project was conceived as a compromise between a pullout and a mainstream program with the main emphasis placed upon classroom teacher applications of ideas gained through mathematics inservices.

Research on the use of manipulative aids in teaching mathematics has shown that the teacher effect is overwhelming (Suydam and Higgins, 1977). Teacher hours of inservice training in this project were limited. The resource teachers felt it would take two or more years participation in the project for the typical classroom teacher to gain the necessary mathematics and methodological background for the proficient use of manipulatives in instruction. Interviews of a sample of teachers participating in the second year of the project supported this assertion. Therefore, both the length and strength of the treatment may be mirrored in the quantitative results.

The Title I "treatment" may be expected to have a long range rather than short term influence upon the achievement of Title I students. Since the main emphasis of the project is on improving teachers competencies in teaching mathematics, it would be useful to include ethnographic observational techniques as part of any future evaluation design to try to understand the impact of the project upon classroom mathematics instruction and student's response to it.

The covariance analysis made small difference in the NCE gain (Grade 3) or loss (Grade 5) reported on the Model B forms to the State Education Agency. Ironically, or perhaps fittingly, the gains and losses cancelled each other out yielding on aggregated gain of .1 NCE. The test instrumentation used in evaluating the third grade project more adequately matched the project's emphasis on concept development than did the single subtest, computation, used for evaluating Grade 5. However, the slight advantage shown by this pilot group on the Concepts and Applications subtest is suggestive. Then, too, the emphasis of the project on using manipulatives in instruction seemed to be more readily applied by third grade teachers. Research on teacher effectiveness has indicated differential effectiveness of instructional methods and groupings of students for instruction in primary and intermediate grades (Tikunoff, et al, 1975; Denham, 1979).

A limitation of Model B is its exclusive focus on the NCE gain score without mention of the need to test for statistical significance of the differences when interpreting results for program improvement. Nor is there any mention of testing for violations of assumptions when using covariance analysis. However, these problems are readily resolved.

Conclusions

The experimental attitude engendered by the use of the Model B evaluation design pervaded project implementation of the project in a way that increased staff effort to provide a project that would have an impact upon the achievement of the target group. Teachers and mathematics

specialists seemed to feel that the evaluation design was a more stringent test of the program that the typical pre- and posttest evaluation design where there is no local comparison group. The notion that educators should pilot-test compensatory education program before implementing them widely could be beneficial to developing more effective programs.

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